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A Tortoise Survey of Shwe Settaw Wildlife Sanctuary, Myanmar, with Notes on the Ecology of *Geochelone platynota* and *Indotestudo elongata*

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The current conservation status of most turtles in Myanmar (formerly known as Burma) is unknown, and old fragmentary observations remain the principal source of information (McCord, 1997; van Dijk, 1997; Platt et al., 2001). The Burmese star tortoise (*Geochelone platynota*) is endemic to the dry zone of central Myanmar, and is considered one of the least known of all living tortoises (Groombridge, 1982; Moll, 1989a). The elongated tortoise (*Indotestudo elongata*) is found in much of Southeast Asia, and probably occurs or formerly occurred in a variety of habitats throughout Myanmar (Moll, 1989b; Iverson, 1992; van Dijk, 1993). Populations of *G. platynota* and *I. elongata* in Myanmar are now believed to be declining due to habitat destruction and over-exploitation, and both species are currently listed on Appendix II of CITES, as are all tortoises excepting those on Appendix I (Groombridge, 1982; Moll, 1989a,b; CITES, 2001). Consequently, status surveys and life history studies have been accorded high priority (Groombridge, 1982; Moll, 1989a,b; van Dijk, 1997). We herein report the results of a recent survey to assess the conservation status of tortoises in the Shwe Settaw Wildlife Sanctuary (SSWS), gather life history data, and provide conservation recommendations based on these findings.

Methods

Study Area. — Shwe Settaw Wildlife Sanctuary (20°11'N, 94°28'E) was established in 1940 for the protection of Eld's deer (*Cervus eldi thamin*) (Salter and Sayer, 1986). SSWS is located on the western edge of the central dry zone within the rain shadow of the Arakan Mountains (FAO/UNDP, 1982). The total area of the sanctuary was originally 553 km^2 (FAO/UNDP, 1982), but this was recently reduced by the sale of 178 km^2 to an agricultural development consortium (Platt, 1999).

Low hills and deep ravines characterize the terrain in SSWS. Elevation ranges from 100 to 550 m above sea level (FAO/UNDP, 1982). Mean annual rainfall is ap-

Figure 1. Dry deciduous or *indaing* forest in Shwe Settaw Wildlife Sanctuary, Myanmar (August 1999). Note low, open canopy and dense grass understory.

proximately 90 cm, and the dry season extends from December through April.

There are no permanently flowing streams in the sanctuary and available surface water is extremely limited during much of the year (FAO/UNDP, 1982). SSWS is characterized by dry deciduous forest, known locally as *indaing* (Fig. 1), and dominated by fire-resistant trees such as *Dipterocarpus tuberculatus*, *Shorea oblongifolia*, *Pentacme siamensis*, and *Tectona hamiltoniana*. Canopy height rarely exceeds 6 m, and the understory consists of low shrubs and grass. Dense vegetation and stands of bamboo (*Bambusa tulda*; *Dendrocalamus strictus*; *Thyrostachys oliveri*) occur on lower slopes and along ephemeral watercourses (FAO/UNDP, 1982; Salter and Sayer, 1986). Selective tree cutting, bamboo harvest, and livestock grazing are widespread, and an undetermined number (+300?) of farmers inhabit the sanctuary. Anthropogenic wildfires are common during the dry season and most of the sanctuary is burned annually (FAO/UNDP, 1982; van Dijk, 1994).

Methodology. — Fieldwork was conducted from 4 to 28 August 1999 during the wet season when tortoises are reportedly most active (Thirakhupt and van Dijk, 1994). We searched areas of SSWS where local hunters had encountered tortoises in the past. Survey participants varied from one to 11, and searchers were accompanied by one or two hunting dogs trained to locate tortoises. Searches were conducted in the morning (0745 to 1130 hrs) and afternoon (1430 to 1830 hrs). Search effort was quantified as the of number man- and dog-hours required to locate one tortoise. Captured tortoises were marked by notching a unique combination of marginal scutes (Cagle, 1939), and the following measurements taken: carapace length (CL) and width, plastron length and width, shell depth, and body mass. Sex of adult *G. platynota* and *I. elongata* was determined based on differences in shell and tail morphology. Males exhibit an obvious plastral concavity and a pronounced thickening of the posterior margin of the anal notch. Males also have longer, thicker tails than females. Feces were obtained when tortoises defecated upon capture, or by placing them overnight in plastic tubs containing approximately 5 cm of water (Thirakhupt and van Dijk, 1994), and examined macroscopically to determine diet. Tortoises were released at the initial point of capture within 24 hours. We also interviewed villagers, hunters, and turtle traders in the surrounding towns and villages to obtain information on tortoise exploitation. Available shells and living tortoises were examined, measured, and photographed.

Results and Discussion

Population Survey. — During this survey we examined 30 *Geochelone platynota* (16 living tortoises and 14 shells) and 44 *Indotestudo elongata* (15 living tortoises and 29 shells), all originating from the general area of SSWS. Living tortoises were examined at SSWS Headquarters (11 *G. platynota*; 5 *I. elongata*), Yangon Zoo (1 *G. platynota*; 3 *I. elongata*), and Chaung Zon Village (1 *I. elongata*), or captured during our survey of the sanctuary (4 *G. platynota*; 6 *I. elongata*). Shells were obtained from villages surrounding the sanctuary.

Our sample of *G. platynota* (Table 1) included 10 males, 10 females, and 10 juveniles that could not be reliably sexed. Mean (± 1 SD) female CL (189 ± 52 mm; range = 96–257 mm) was significantly greater (ANOVA; $F = 15.5$; $df = 1, 18$; $p < 0.001$) than that of males (150 ± 41 mm; range = 86–192 mm). Our sample of *I. elongata* included 9 males, 4 females, and 31 specimens, mostly shells without plastrons, which could not be reliably sexed (Table 2). The small number of

Table 1. Morphometric data (in mm and kg) for *Geochelone platynota* (living tortoises and complete shells) examined in western Myanmar during August 1999. Six recently hatched juveniles are not included (see text).

Attribute	Mean ± 1 SD	Range
Living tortoises (n = 10)		
Carapace length	156 ± 57	66–257
Carapace width	107 ± 33	56–172
Plastron length	132 ± 47	54–206
Plastron width	94 ± 31	47–152
Shell depth	82 ± 27	39–131
Mass (kg)	0.9 ± 0.7	0.07–2.6
Complete shells (n = 14)		
Carapace length	140 ± 55	51–237
Carapace width	94 ± 28	48–153
Plastron length	118 ± 44	47–192
Plastron width	84 ± 26	41–136
Shell depth	70 ± 22	31–110

Table 2. Morphometric data (in mm and kg) for *Indotestudo elongata* (living tortoises, complete shells, and carapaces lacking plastrons) examined in western Myanmar during August 1999.

Attribute	Mean ± 1 SD	Range
Living tortoises (n = 15)		
Carapace length	154 ± 46	68–220
Carapace width	103 ± 25	54–146
Plastron length	123 ± 34	59–169
Plastron width	92 ± 22	50–126
Shell depth	67 ± 18	36–97
Mass (kg)	0.7 ± 0.5	0.07–1.7
Complete shells (n = 11)		
Carapace length	162 ± 44	65–214
Carapace width	109 ± 22	59–139
Plastron length	130 ± 32	55–161
Plastron width	96 ± 21	51–125
Shell depth	66 ± 16	31–87
Carapaces (n = 18)		
Carapace length	195 ± 30	119–256
Carapace width	126 ± 17	91–167

I. elongata that could be sexed precluded meaningful statistical comparisons. Our sample was dominated by intermediate sized tortoises (Fig. 2). The mean (± 1 SD) carapace lengths of *G. platynota* (154 ± 58 mm; range = 86–257 mm; n = 24) and *I. elongata* (174 ± 43 mm; range = 65–256 mm; n = 44) were considerably less than the respective adult carapace lengths of 260 to 280 mm, and 270 to 360 mm, reported by others (Ernst and Barbour, 1989; Moll, 1989a,b; Cox et al., 1998).

We made 11 captures of tortoises during this survey, including 5 *G. platynota* (four individuals and one recapture) and 6 *I. elongata* (Table 3). Searchers found 4 *G. platynota* during 402.2 man-hours of fieldwork (100.5 man-hours required to find each *G. platynota*). Dogs located 1 *G. platynota* and 6 *I. elongata* during 72.0 dog-hours of searching (72.0 dog-hours to find one *G. platynota* and 12.0 dog-hours to find each *I. elongata*). An adult male *G. platynota* (CL = 160 mm) was recaptured 1.48 km (straight-line distance) from where it was released 48 hours earlier.

The ecological relationship between *G. platynota* and *I. elongata* is poorly understood. Theobald (1868) stated that local hunters captured *G. platynota* and *I. elongata* by burning "grass jungles and forest." Moll (1989a) noted that it is unclear from this early account if both species occurred in each habitat, or if one was restricted to grasslands and the other to forests. We found no evidence of habitat partitioning by *G. platynota* and *I. elongata* in SSWS. Captures of both occurred in the same general area, and in a variety of microhabitats, including bamboo thickets, wooded slopes, and open grasslands.

Reproduction. — Almost nothing is known concerning reproduction of *G. platynota* in the wild. Smith (1931) stated that a clutch of eggs, "few in number" and each measuring approximately 40 mm wide by 55 mm long, is deposited at the end of February. During our survey we examined six juveniles maintained at SSWS Headquarters that were collected from a nest in May 1999. Mean (± 1 SD) juvenile morphometrics were: carapace length = 54.5 ± 1.6 mm; carapace width = 48.8 ± 1.1 mm; plastron length = 47.5 ± 1.7 mm; plastron width = 41.1 ± 1.7 mm; shell depth = 32.1 ± 1.3 mm; mass = 44.1 ± 3.7 g. The nest was located in a ridgetop clearing surrounded by open *Tectona hamiltoniana* forest, and excavated in heavy clay soil. We found dense grass covering the site during our inspection on 6 August; however, the area had recently burned when the nest was discovered three months previously. The neonates had hatched, but were still in the nest cavity when found by a sanctuary ranger. It is possible that hatchlings remain in the nest cavity until the onset of the wet season (late May or early June) when conditions are more favorable for survival.

Food Habits. — Feces were obtained from 4 *G. platynota* and 2 *I. elongata* captured in SSWS. The feces of 3 *G. platynota* consisted largely of grass; several pieces of insect chitin were found in one scat. The feces of a fourth *G. platynota* contained unidentified plant material. Three *G. platynota* defecated small stones (> 0.5 g) which may have been ingested accidentally during feeding, or perhaps consumed deliberately to facilitate digestion of plant material. The scat of one *I. elongata* was composed largely of grass, but also included two unidentified leaves and pieces of

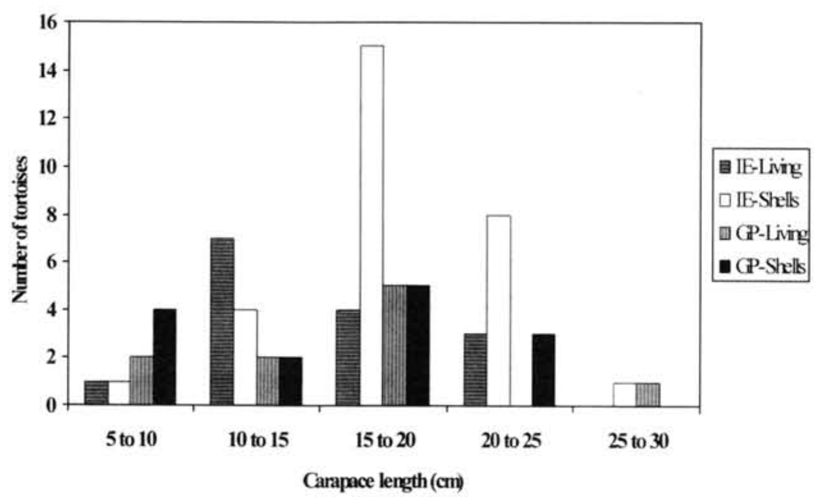

Figure 2. Size distribution (carapace length in cm) of *Geochelone platynota* (GP; 10 living tortoises and 14 shells) and *Indotestudo elongata* (IE; 15 living tortoises and 29 shells) from Shwe Settaw Wildlife Sanctuary and surrounding area. Six recently hatched juveniles not included. Note the lack of tortoises in the larger size categories (CL > 25 cm).

Table 3. Morphometric data for *Geochelone platynota* and *Indotestudo elongata* captured during field survey of Shwe Settaw Wildlife Sanctuary, Myanmar, in August 1999. M = male; F = female; J = juvenile, too small to reliably determine sex; CL = carapace length; CW = carapace width; PL = plastron length; PW = plastron width; SD = shell depth. Shell attributes given in mm; mass in grams.

Species number	Sex	CL	CW	PL	PW	SD	Mass
Geochelone platynota							
1	F	163	110	140	97	87	850
2	M	160	103	134	95	80	710
3	J	89	67	76	57	52	160
4	J	66	56	54	47	39	75
Indotestudo elongata							
1	M	194	127	154	116	82	1250
2	M	220	146	169	126	96	1700
3	M	127	92	104	83	59	350
4	M	143	99	118	88	65	495
5	J	110	88	99	78	55	220
6	J	68	54	59	50	36	70

mushrooms, while the other scat consisted solely of mushrooms. According to hunters, both species also feed heavily on grass sprouts, especially at the beginning of the wet season, the fallen flowers of *thakut* (*Dolichandrone spathacea*), *thit pagan* (*Millettia brandisiana*), and *mahlwa* (*Markhamia stipulata*), fruits of *lelu* (*Olax scandens*), and flowers and foliage of wild onion (*Allium* spp.). Hunters also report finding tortoises consuming eggshells in red junglefowl (*Gallus gallus*) nests following hatching. The food habits of wild *G. platynota* have not been previously reported. Elsewhere, *I. elongata* consume herbaceous leaves, fruits, flowers, fungi, and slugs (Nutphand, 1979; Ernst and Barbour, 1989; Moll, 1989b; P.P. van Dijk, *pers. comm.*).

Effect of Wildfires. — Dry season wildfires constitute a significant source of mortality for many tortoise populations in Asia (Thirakhupt and van Dijk, 1994; Chan-ard et al., 1996; Mitchell and Rhodin, 1996; Das, 1997). According to Theobald (1868) "vast numbers [of tortoises] perished" during fires deliberately set by hunters in Burma. The effect of annual burning on populations in SSWS remains unknown, but undoubtedly some tortoises are killed. The intact shell of a juvenile *G. platynota* (CL = 51 mm) was found on a hillside burned in May 1999, and the tortoise was probably killed in the fire. Additionally, shell anomalies suggestive of fire injuries (Dodd et al., 1997; Lambert et al., 1998) were noted on four *I. elongata* and one *G. platynota*. Hunters report occasionally finding dead tortoises following wildfires, but maintain that grass fires kill few adults. According to hunters, during the dry season tortoises move into streamside vegetation or burrow beneath leaves that accumulate in ravines. While surface water is absent during this period, these relatively mesic micro-sites may confer some protection from intense fires.

Exploitation. — Rural Burmese have long exploited tortoises for food. Theobald (1868) stated that large numbers were captured with the aid of dogs, and according to Blythe (1863) specimens of *G. platynota* were difficult to obtain because locals were "so fond of eating them." Widespread subsistence harvesting of tortoises for food in SSWS occurred in the past. This largely opportunistic hunt was confined to larger adults; smaller adults and juveniles were not collected. Tortoises were collected when villagers entered SSWS to cut bamboo, herd cattle, or collect fuelwood. This harvest probably resulted in a significant long-term decline in tortoise populations, because of the large number of people involved, who penetrated even the remotest regions of SSWS. Our village interviews support this scenario, as many older residents stated tortoises were abundant and easy to find 30 to 40 years ago, but are now difficult to locate. Furthermore, informants had not encountered *G. platynota* outside SSWS in recent years, although *I. elongata* is still occasionally collected.

Commercial exploitation of tortoises is a recent phenomenon in the region. A network of turtle traders was established during 1998 in villages surrounding SSWS, and they began buying tortoises of any size. Although the current harvest is difficult to quantify, large numbers of tortoises are being collected at what are almost certainly unsustainable levels. Many engaged in this trade are professional hunters who obtain most of their livelihood from the sale of wildlife, and the use of dogs, an extremely efficient collecting technique, is widespread. One hunter we interviewed claimed to have taken 500 to 600 tortoises (about 300 *G. platynota*) in 1999, and another caught two or three each day during May and June. The number of professional hunters operating in the area is unknown, but each village appears to have at least one or two individuals who specialize in collecting tortoises.

Traders purchase tortoises by weight and typically pay the equivalent of US $5.30 per kg, a substantial sum in a country where trained office personnel receive the equivalent of about US $70.00 per month. Tortoises are then shipped overland to the northeastern frontier and sold to dealers in Ruili, a border town in Yunnan Province, China, that hosts an extensive wildlife market (Kuchling, 1995; STK, *pers. obs.*). Juvenile and small adult *G. platynota* are in high demand for the export pet trade; *I. elongata* and some larger *G. platynota* are sold locally in Ruili, or shipped to other food markets in southern China.

Tortoise plastrons, an ingredient of many traditional Chinese medicines (Thirakhupt and van Dijk, 1994), are also exported from Myanmar. Buyers periodically visit villages to purchase plastrons, and the plastrons of most *I. elongata* shells we examined had already been sold. Das (1997) reported *G. platynota* shells in medicine shops of Yunnan, China. Some plastrons are used locally; villagers pulverize and boil them, and then mix them with pig food as a prophylactic against various unspecified diseases.

Although the absence of baseline data makes conclusions regarding population trends somewhat speculative, the available evidence strongly suggests tortoise populations have been drastically reduced in SSWS. First, the general consensus among villagers and hunters is that tortoises are now much less common than previously. This is apparently a long-term trend, undoubtedly exacerbated by recent commercial demand. Second, the large amount of search effort required to find tortoises indicates densities are low. Likewise, Klemens and Moll (1995) noted that exploited pancake tortoise (*Malacochersus tornieri*) populations in Tanzania yielded fewer specimens per man-hour of search effort than unexploited populations. Comparative data from unexploited tortoise populations in Myanmar do not exist. Finally, the size distribution and small mean body size noted among both species in SSWS is highly suggestive of an over-exploited population, with harvesting pressure so intense that few tortoises are able to attain adult body size before being collected. Similarly, Thirakhupt and van Dijk (1994) noted the rarity of large adult *I. elongata* among exploited populations outside of protected areas in Thailand, and Close and Seigel (1997) found the mean carapace length of *Trachemys scripta elegans* from exploited populations was significantly smaller than in protected populations.

Undoubtedly, over-harvesting is the single most important threat to the continued viability of *G. platynota* and *I. elongata* populations in SSWS. Life history traits of long-lived organisms such as tortoises severely constrain the ability of populations to respond to chronic over-harvesting (Congdon et al., 1993). Furthermore, there is no evidence of a compensatory response among juveniles to increased adult mortality (Brooks et al., 1991). Therefore, the ability of turtle populations to withstand even low to moderate levels of increased mortality remains doubtful (Klemens and Moll, 1995), and it is questionable whether any harvest can be considered sustainable (Thorbjarnarson et al., 2000).

Habitat destruction and fragmentation further threaten the regional viability of tortoise populations. Approximately 178 km^2 in the northeastern part of SSWS was recently sold to a development company and cleared for agriculture. It is also doubtful whether viable tortoise populations remain in the region surrounding the sanctuary. This area is densely populated and most land is devoted to row crop agriculture, hillsides are heavily grazed, and fuelwood collection has seriously degraded the remaining forests, now reduced to low, woody scrub. Continued land degradation will result in further insularization of SSWS, and increase pressure from villagers for access to resources within the sanctuary.

Conservation Status Elsewhere in Myanmar. — Owing to the paucity of survey data, it is difficult to provide a national assessment of the current conservation status of tortoises in Myanmar (Platt et al., 2000). However, the few reports available indicate both *I. elongata* and *G. platynota* are being subjected to unsustainable levels of harvest and populations are depleted throughout much of their historic distribution. According to van Dijk (1993), *I. elongata* "is becoming increasingly scarce...[and over-harvesting]... appears to have depleted populations in most areas." In 46 weeks of intensive collecting in the Chattin Wildlife Sanctuary (23°34'N, 95°44'E), Zug et al. (1998) found only a single juvenile *I. elongata*, and concluded the species was "uncommon" due to over-harvesting for food. Van Dijk (1993) stated *G. platynota* and *I. elongata* occur in the hills surrounding Kywe-nah-pah (21°45'N, 96°20E) where they are hunted intensively with dogs. Tortoises from this region are small with carapace lengths never exceeding 250 mm (van Dijk, 1993). Nearby Mya Leik Taung (Emerald Turtle Mountain) functioned as a *de facto* sanctuary where tortoises were protected by local religious beliefs (van Dijk, 1993). However, because of current market demand, hunters are now collecting tortoises from the mountain (U Hla Win, deputy Director General, Myanmar Fisheries Department, *pers. comm.*).

Conservation Recommendations. — Both *G. platynota* and *I. elongata* should be considered critically endangered in Myanmar due to over-harvesting for local consumption and export, and habitat destruction. *Geochelone platynota* is particularly vulnerable because only two extant populations (SSWS and vicinity of Kywe-nah-pah) are definitely known, and both are subject to continuing exploitation. Full legal protection of *I. elongata* and *G. platynota* in Myanmar is therefore clearly warranted. Most importantly, rigorous measures must be instituted by conservation authorities in China and Myanmar to regulate the trans-border wildlife trade between the two countries. Regardless of legal protection, as long as these markets are in operation, tortoise hunting will remain a lucrative economic proposition for rural inhabitants and exploitation will continue. Given market demands and the status of *I. elongata* and *G. platynota*, the implementation of a zero export quota by Myanmar authorities is recommended. Without rapid implementation of protective measures, tortoise populations may disappear before even basic ecological studies can be undertaken.

SSWS offers the best opportunity for *in situ* conservation of *G. platynota* in Myanmar. All harvest should immediately cease, and protective measures must be coupled with effective enforcement. Land-use practices must also be compatible with tortoise conservation. While timber and bamboo harvesting do not appear to pose a direct threat to tortoises, people engaged in these pursuits may eat tortoises when working in the forest. The effects of livestock grazing and wildfires on tortoises must also be evaluated. Moderate levels of grazing could potentially benefit tortoises by stimulating the growth of grass shoots, a preferred tortoise food. Conversely, wildfires may represent a significant source of mortality and necessitate implementation of control programs. Finally, if effective conservation measures can be instituted, the sanctuary would be an excellent site for reintroducing captive-bred tortoises to enhance recovery efforts.

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